The role of extruded disk material in thoracolumbar intervertebral disk disease: A retrospective study in 40 dogs

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Abstract — The objective of the study was to determine the effect of the dispersed or nondispersed form of the extruded disk material (EDM) on the neurological status and surgical outcomes in Hansen thoracolumbar intervertebral disk disease Type I (IVDD-I). Medical records of 40 dogs with IVDD-I were reviewed, including neurologic status on admission, findings on magnetic resonance imaging (MRI), intraoperative findings, and surgical outcomes. In MRI evaluations, EDM was on the right in 16, on the left in 18, and centrally in 6 cases; in all cases, findings were confirmed by surgery. Extruded disk material was localized and classified as dispersed disk (DD) or nondispersed disk (NDD) according to its dispersion in the epidural space on MRI. Twenty-five dogs had DD and 15 had NDD on both MRI and surgery. There was no significant difference between DD and NDD in preoperative neurological status and surgical outcomes ($P > 0.05$).

Résumé — Effet du matériel discal expulsé dans la maladie discale intervertébrale thoracolombaire : étude rétrospective chez 40 chiens. L'objectif de cette étude était de déterminer les effets de la forme dispersée et non-dispersée du matériel discal expulsé (MDE) sur l'état neurologique et le résultat chirurgical de la maladie discale intervertébrale thoracolombaire de Hansen de type 1 (MDIV-1). Les dossiers médicaux de 40 chiens avec MDIV-1 ont été revus en ce qui concerne l'état neurologique à l'admission, les trouvailles de l'observation à la résonance magnétique (ORM), les trouvailles opératoires et le résultat chirurgical. Selon les ORM, le MDE était à droite dans 16 cas, à gauche dans 18 et au centre dans 4; dans tous les cas ces observations ont été confirmées par chirurgie. En se basant sur les ORM le matériel discal expulsé était localisé et classifié comme discal dispersé (DD) ou discal non-dispersé (DND) selon sa dispersion dans l'espace épidural. Vingt-cinq chiens présentaient un DD et 15 un DND à la fois en ORM et en chirurgie. Il n'y avait pas de différence significative entre un DD et un DND dans l'état neurologique préopératoire ainsi que dans le résultat chirurgical ($P > 0,05$).

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Introduction

Hansen type I and Hansen type II disk diseases refer to extrusion of the nucleus pulposus and protrusion of the annulus fibrosus, respectively (1). Many papers have described the clinical, radiographic, and pathologic features; the management; and the prognosis of intervertebral thoracolumbar disk disease Type I (IVDD-I) (2–8). The effect of the locale of the EDM in the epidural space on the clinical signs and histological appearance of the EDM has been described (5,9,10). The distribution of EDM as a button–shaped lesion over the affected disk space is classified as Type I, with extension over adjacent vertebrae as Type II, and widely distributed over the several vertebrae as Type III (9). Canine IVDD is also classified, according to the onset of clinical signs, as peracute (onset of signs in less than 1 h), acute (onset of signs in between 1 and 24 h), and chronic (onset of signs after more than 24 h) (4,11,12).

Conventional radiography with myelography has traditionally been used for the diagnosis of IVDD, though misleading results have been reported occasionally (6,13,14). Recently, magnetic resonance imaging (MRI) has come into wider use in veterinary practice as a diagnostic tool (15–19). Sether et al (16) determined that MRI was the best available method for early recognition of disk degeneration in dogs. It also provides clear images of soft tissues and enables precise distinction of anatomical and pathological changes of the brain and spinal cord (14,17,18,20). Surgical decompression with removal of EDM is a well-accepted treatment of choice for patients with severe or progressive neurologic deficits (20–22). However, decompression with concomitant disk fenestration as a prophylactic measure remains controversial (4,20,23,24). Recently, prophylactic disk fenestration has been found to be a successful method for preventing future disk extrusions at the fenestrated disk space (25).

The results of MRI in a large group of dogs with IVDD-I have not been published previously. In addition, the border of dispersion has not been discussed in detail, except for histological evaluation in veterinary neurosurgical practice (5,9). The purpose of this study was to

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determine, retrospectively, the extent of EDM in the epidural space in 40 dogs with thoracolumbar IVDD-I and the effect of its dispersion on the clinical signs and surgical outcomes, and to compare MRI, clinical, and intraoperative findings.

Materials and methods

Medical records of dogs with thoracolumbar IVDD that were admitted to the Department of Surgery, Faculty of Veterinary Medicine, Ankara University between March 1997 and June 2004 were reviewed. Criteria for inclusion in the study were as follows: clinical signs for more than 24 h, IVDD-I (in only I intervertebral disk space [IVD]), and diagnosis by MRI.

Reviewed for each dog were the age; breed; sex; time from onset of clinical signs to admission; neurological status; dispersion and lateralization of the EDM, determined by MRI and qualitative comparison during surgery; and surgical outcomes.

The degree of neurological deficits was graded by the same surgeon as follows: Grade (G) 0 — no neurologic dysfunction or pain; G I — thoracolumbar pain with no neurological deficit; G II — ambulatory paraparesis; G III — nonambulatory paraparesis; G IV — paraplegia with or without bladder control; and G V — paraplegia with loss of both bladder control and deep pain perception. Deep pain perception was assumed to be intact, if the dog exhibited a conscious response (biting, vocalizing) to the clamping of its pelvic limb digits with surgical forceps.

Magnetic resonance imaging procedures

Anesthesia was induced by administering diazepam (Diazem; Deva, Istanbul, Turkey), 0.2 mg/kg bodyweight (BW), and propofol (Diprivan; Zeneca-Abdi Ibrahim, Istanbul, Turkey), 5 mg/kg BW, IV, and maintained simultaneously by constant infusion of 0.3 to 0.4 mg/kg BW/min with a drip set. The images of all dogs were obtained with an MRI unit (Siemens Superconducting Magnet, field strength of 1.5 tesla; Siemens AG, Munich, Germany), using a surface coil. T_1-weighted sagittal projections were obtained with a repetition time of 400 to 700 ms and an echo time of 10 to 14 ms. T_2-weighted sagittal projections were obtained by using a repetition time of 3000 to 4000 ms and an echo time of 90 to 99 ms. T_1-weighted transverse images were obtained using repetition times of 370 to 700 ms and an echo time of 12 to 20 ms. T_2-weighted transverse images were obtained by using a repetition time of 2000 to 4000 ms and an echo time of 90 to 98 ms. T_1 and T_2 weighted images of spinal cord, EDM, and IVD were evaluated. Results from the MRI were evaluated in consultation with a certified human medical imaging specialist from the Medical Faculty at Hacettepe University, Turkey.

The horizontal and vertical lengths of the EDM in the vertebral canal were measured by using manual calipers on sagittal images. The dispersion of disk material in the vertebral canal was calculated as vertical dispersion (height of the extruded material to the height of vertebral canal) and horizontal dispersion (horizontal length of the extruded material to the vertebral body length) (Figure 1). Thoracolumbar IVDD-I was subclassified according to the dispersion of the EDM in the vertebral canal: When the disk material extruded, lost its contact with the parent IVD, and spread out along the epidural space, it was defined as a dispersed disk (DD); when disk material was extruded but not dispersed through the vertebral canal, remained just around the intervertebral disk space, and was still in contact with the parent IVD, it was defined as nondispersed disk (NDD). In cases of hemorrhage mixed with disk material, the end-point of the EDM was taken into account rather than the hemorrhage. The localization of the EDM was determined as being in a central, left side, or right side position in the epidural space. The affected part of the spinal cord was also compared with the cord in the adjacent area, and examined according to the presence of increased signal intensity on T_2-weighted images.

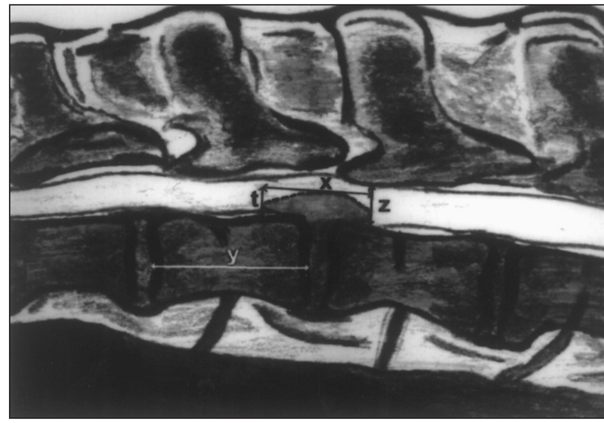

Figure 1. Schematic representation of measurement technique of extruded disk material: Height of the extruded material (t), height of vertebral canal (z), horizontal length of the extruded material (x), and vertebral body length (y), vertical dispersion: (t/z), horizontal dispersion: (x/y).

Anesthesia for operation

All dogs were premedicated with atropine sulphate (Atropin Injectable; Vetas, Istanbul, Turkey), 0.01 to 0.02 mg/kg BW, and fentanyl (Fentanyl Citrate; Abbott, Istanbul, Turkey), 0.005 mg/kg BW, IV. Anesthesia was induced with propofol, 5 mg/kg BW, IV, and maintained after endotracheal intubation with halothane (Halotan; Hoechst Istanbul, Turkey) in oxygen.

The dogs received methylprednisolone (Prednol L, 250 mg; Mustafa Nevzat, Istanbul, Turkey), 30 mg/kg BW, IV, and cephalosporin (Cefizox, 500 mg; Eczacıbasi, Istanbul, Turkey), 30 mg/kg BW, IV, before induction of anesthesia, as a single dose. Amoxicillin (Amoksina; Mustafa Nevzat), 22 mg/kg BW, PO, q12h, and carprofen (Rimadyl; Pfizer, Zaventem, Belgium), 4 mg/kg BW, PO, q12h, were continued for 3 d postoperatively for prophylactic purposes and to maintain analgesia; ranitidine (Ranitab; Deva, Istanbul, Turkey), 2 mg/kg, PO, q12h for 3 d, was administered to protect the alimentary tract from NSAID-induced gastritis.

Surgery

Hemilaminectomy or laminectomy was performed according to the lateralization of the EDM. In hemilaminectomy, the facet joint was not preserved, and decompression was achieved by rongeuring (26,27). For laminectomy, the modified Funquist B technique

Table 1. Cases' summary data

Case number	AD	NS	D	Lc	IVDD-I	HD = x/y	VtD = t/z	S.O	Intensity
1	2	III	NDD	L	L_{1-2}	0.51	1.00	0	Hyperintense
2	3	III	DD	L	$T_{13\text{-}L1}$	0.78	0.93	0	Hyperintense
3	4	II	DD	R	L_{1-2}	0.98	0.75	0	Normal
4	2	III	DD	L	T_{12-13}	0.78	0.91	0	Normal
5	2	II	DD	R	T_{11-12}	1.00	0.81	0	Normal
6	3	II	DD	L	$T_{13\text{-}L1}$	0.67	0.88	0	Normal
7	1	III	NDD	C	$T_{13\text{-}L1}$	0.37	0.41	0	Normal
8	3	III	NDD	C	L_{3-4}	0.57	0.40	IV	Hyperintense
9	10	III	NDD	R	T_{12-13}	0.43	0.80	0	Normal
10	5	III	DD	L	L_{1-2}	0.85	0.66	0	Normal
11	1	IV	DD	L	L_{2-3}	0.81	0.59	II	Hyperintense
12	5	III	DD	L	L_{2-3}	1.00	0.54	0	Normal
13	30	II	NDD	R	L_{1-2}	0.52	0.72	0	Normal
14	10	II	DD	C	L_{6-7}	0.71	0.41	0	Normal
15	3	III	DD	L	T_{12-13}	1.00	1.00	0	Normal
16	4	III	DD	L	L_{1-2}	1.68	0.60	II	Hyperintense
17	1	IV	NDD	R	L_{1-2}	0.34	0.43	0	Normal
18	4	II	DD	L	L_{4-5}	0.80	0.54	0	Normal
19	2	III	DD	R	L_{4-5}	1.22	0.54	0	Normal
20	10	IV	DD	L	L_{3-4}	1.34	0.53	IV	Hyperintense
21	3	III	DD	R	L_{2-3}	0.96	0.68	0	Normal
22	2	III	NDD	L	L_{3-4}	0.52	0.47	II	Normal
23	4	III	NDD	R	T_{12-13}	0.46	0.44	IV	Hyperintense
24	2	III	DD	R	T_{11-12}	1.18	0.60	0	Hyperintense
25	2	IV	DD	L	T_{11-12}	0.85	0.76	IV	Normal
26	6	IV	DD	L	$T_{13\text{-}L1}$	0.92	0.63	0	Normal
27	2	III	NDD	C	$T_{13\text{-}L1}$	0.41	0.56	0	Normal
28	3	III	DD	L	$T_{13\text{-}L1}$	1.38	0.78	0	Normal
29	3	III	DD	R	L_{4-5}	0.80	0.74	0	Normal
30	7	II	NDD	R	$T_{13\text{-}L1}$	0.54	0.69	0	Normal
31	3	III	NDD	L	L_{1-2}	0.23	0.37	0	Hyperintense
32	7	III	DD	R	L_{2-3}	0.82	0.744	0	Normal
33	3	II	NDD	R	L_{6-7}	0.37	0.55	0	Normal
34	7	III	DD	C	T_{12-13}	0.35	0.63	II	Hyperintense
35	3	III	NDD	R	$T_{13\text{-}L1}$	0.24	0.53	0	Normal
36	2	II	NDD	L	T_{12-13}	0.33	0.16	0	Normal
37	3	IV	DD	C	L_{2-3}	0.23	0.33	II	Hyperintense
38	5	III	DD	R	T_{11-12}	0.75	0.625	I	Normal
39	3	III	NDD	L	T_{12-13}	0.22	0.90	I	Normal
40	2	III	DD	R	T_{11-12}	0.40	1.00	0	Normal

AD — Admission day; D — Dispersion of disk material; NS — Neurological status at admission day; Lc — Localization of disk material; L — Left; R — Right; C — Central; IVDD-I — Hansen thoracolumbar intervertebral disk disease type I; DD — Dispersed disk; NDD — Nondispersed disk; SO — Surgical outcomes as neurological status; VtD — Vertical dispersion; t — Height of the extruded disk material; z — Height of the vertebral canal; HD — Horizontal dispersion; x — Horizontal length of the extruded disk material; y — Length of the vertebral body

(removal of dorsal lamina and caudal articular process with excavation of the lateral lamina and pedicle) was used, and the procedure was carried out with an air speed drill and rongeuring together (28). The length of the decompression was determined by the extent of the EDM and the borderline appearance of normal fat tissue, or by the space required to retrieve the EDM with minimal manipulation of the spinal cord. Fenestration was not carried out in the affected IVD or the adjacent IVDs. Fat tissue was implanted into the decompression defect to reduce epidural fibrosis. Surgical findings, including the qualitative border and the location of the EDM, were compared with the MRI findings. All cases were discharged from hospital on the 2nd day and the owner was instructed to evacuate the bladder, if the patient was without voluntary control. Postoperative rehabilitation, including hydrotherapy, muscle massage, and joint extension-flexion, was suggested to the owner.

The dogs were followed for at least 1 mo postoperatively with neurological examinations and were regraded by the same surgeons that did the preoperative assessment. Telephone contact with the owners was continued for 2 mo to 7 y.

The data were analyzed by using analytical software (SPSS for Windows 10.0; SPSS, Chicago, Illinois, USA). For parametric analysis, the means of the 2 groups were compared by using Student's *t*-test, while the means of 3 or more groups were compared by analysis of variance (ANOVA). Additionally, the Mann-Whitney U and Kruskal-Wallis analysis of variance tests were constructed correspondingly. While dealing with crosstables, the Pearson χ^2 and Fisher's exact tests were applied. In order to see whether a correlation between horizontal length of the EDM and the vertebral body length, the height of the vertebral canal and height of the EDM, and the horizontal dispersion and the vertical dispersion existed, the Pearson and Spearman correlation tests were used. The sensitivity and specificity of MRI in detecting herniated disk material was calculated by taking operation results as the reference test. All parameters were evaluated by a logistic regression model. For all tests $P < 0.05$ was considered significant.

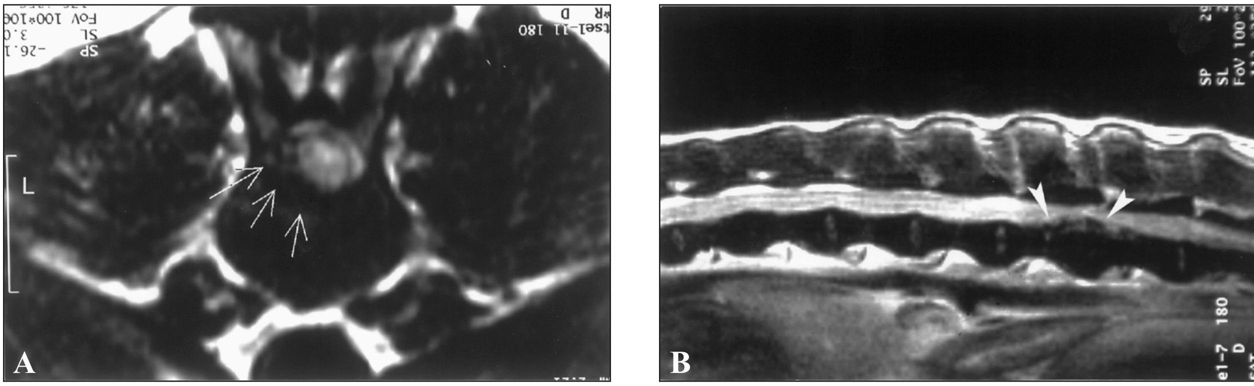

Figure 2. Magnetic resonance imaging of dispersed extruded disk material on the left side (arrow) (2a) on transverse T_2-weighted images and, its spread out along the epidural space on sagittal T_2 weighted images (dispersed disk — arrows) at the level of affected intervertebral disk disease (2b).

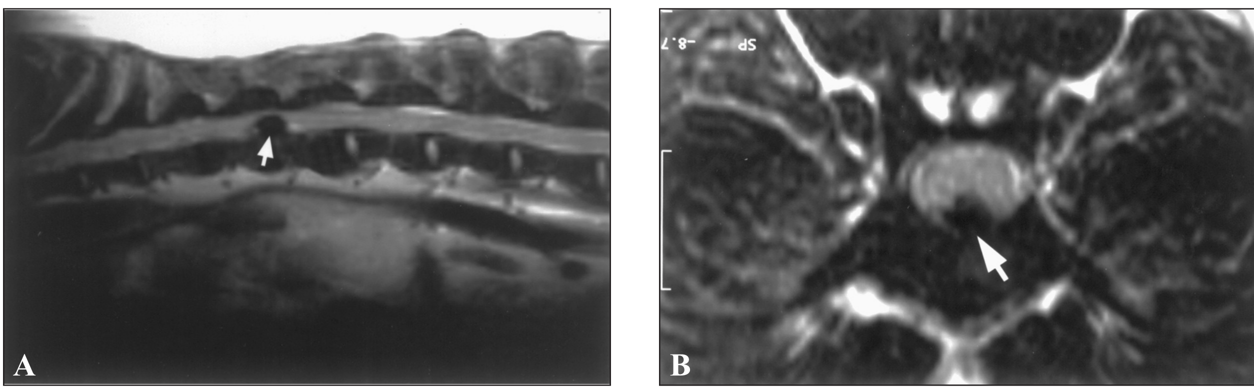

Figure 3. Magnetic resonance imaging of sagittal (a) and transverse (b), T_2 weighted images; T_{12-13} intervertebral disk space is narrowed and extruded disk material stayed just around the intervertebral disk space appearing hypo-intense without spreading out along the epidural space (nondispersed disk — arrow). On transverse image extruded disk material was depressing to the spinal cord centrally (arrow).

Results

Forty dogs (26 male, 14 female) met the criteria for inclusion in the study. The age of the dogs ranged from 3 to 10 y (mean 5.8 y). Breeds of dogs described in this study were Pekingese ($n = 19$), dachshund ($n = 5$), miniature poodle ($n = 8$), cocker spaniel ($n = 5$), basset hound ($n = 1$), French bulldog ($n = 1$), and German shepherd ($n = 1$). Thirty-two of the dogs (80%) weighed less than 10 kg. Time from onset of clinical signs to admission was 4.43 d (range 1 to 30 d). At the time of the surgery, 25 dogs (62.50%) were in neurological deficits G III, 9 dogs (22.50%) were in G II, and 6 dogs (15%) were in G IV.

All soft tissue structures (spinal cord, nerve roots, meninges, ligaments, etc.) and the IVD could be distinguished with T_1- and T_2-weighted MRI in 3 dimensions. Precise outlines of the spinal cord, subarachnoid space, and epidural space, and characteristic features of the IVD and spinal cord revealed lesions. Increased signal intensity was observed in 7 DD and 4 NDD cases, as shown in Table 1. Extruded disk material could be distinguished by its low intensity in the epidural space in both DD and NDD cases in T_1- and T_2-weighted images (Figures 2a, 2b, 3a, and 3b). Hematoma appeared as a hyperintense site on both T_1- and T_2-weighted images (Figure 4a and 4b).

There was complete agreement regarding affected IVD, lateralization, and nature of dispersion between MRI and surgical exploration during hemilaminectomy ($n = 35$) and laminectomy ($n = 5$).

Twenty-five dogs (62.50%) had DD and 15 (37.50%) had NDD. The preoperative neurological status of the DD cases was as follows: 15 dogs (60.0%) in G III, 5 dogs (20.0%) in G II, and 5 dogs (20.0%) in G IV. In NDD cases, 10 dogs (66.67%) in G III, 4 dogs in G II (26.67%), and 1 dog (6.67%) in G IV.

Extruded disk material was localized to the left, right, and central position in 18, 16, and 6 IVD, respectively. The most frequently affected IVD in IVDD-I was thoracic $(T)_{13}$-lumbar $(L)_1$ ($n = 8$) followed by L_{1-2} ($n = 7$), T_{12-13} ($n = 7$), L_{2-3} ($n = 5$), T_{11-12} ($n = 5$), L_{3-4} ($n = 3$), L_{4-5} ($n = 3$), and L_{6-7} ($n = 2$). Epidural hematoma was observed accompanying IVDD-I in 1 case.

The relationship was not significant between vertical dispersion or horizontal dispersion and preoperative neurological status ($P > 0.05$, r = 0.127). The means of the horizontal length of the EDM and the lateral compression of the spinal cord by the EDM were statistically greater in DD cases than in NDD cases ($P < 0.05$). Only 3 of 25 DD were localized in the central position, the majority were laterally located. Even though 3 of 15 NDD were located centrally, almost all cases diagnosed

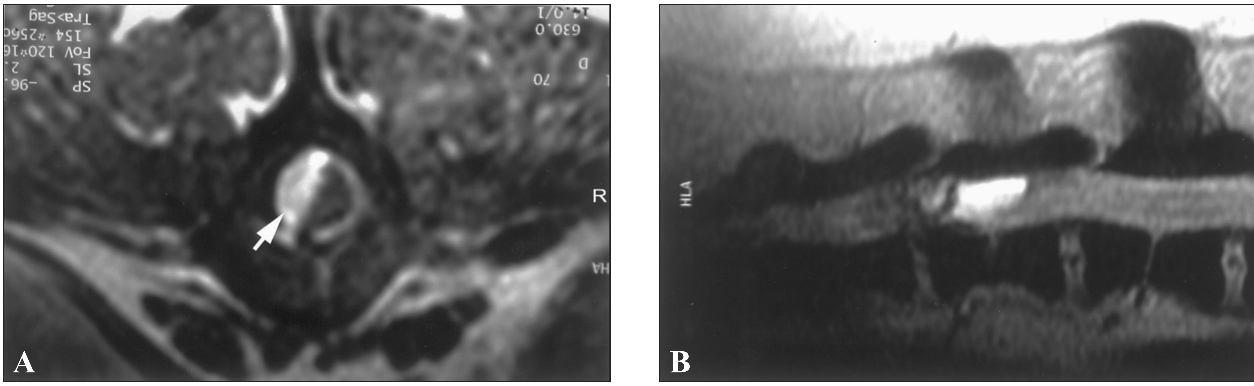

Figure 4. Magnetic resonance imaging of subacute epidural hematoma on the left side, pushing the thecal sac to median (arrow) on transverse T_1-weighted image (a), and sagittal T_2-weighted image (b). Notice the hyperintense images on both sequences are consistent with extracellular methemoglobin.

as laterally positioned were actually centrolateral in position and more calcified than DD. Besides the greater horizontal length of the EDM in DD cases, the vertical dispersion of lateral extrusion was also greater than that of central extrusion ($P < 0.05$). On statistical analysis, the type of dispersion did not significantly affect the surgical outcome ($P > 0.05$). The outcomes for both DD and NDD cases were not different based on completely recovered cases (Table 1).

In DD cases, the EDM was spread out around the level of the affected IVD and was generally combined with hemorrhage and epidural fat tissue in the lateral location (88.0%), as seen in MRI and on a qualitative surgical exploration. Removal of the mass was easier in DD cases than NDD cases, since the DD was laterally located as a thin structure in the epidural space, which was slightly adherent to the duramater and well exposed by hemilaminectomy. By contrast, in the NDD cases, the EDM was generally located centrolaterally, tightly adherent to dorsal longitudinal ligament, duramater, and other structures. In contrast to the DD, these features made the NDD EDM difficult to remove from the epidural space. All of the EDM that was imaged was retrieved during surgery in all cases.

Of the 40 dogs included in the study, 29 dogs fully recovered within 1 mo postoperatively, except for 1 that recovered within 2 mo postoperatively. Seven dogs displayed neurological improvement but no functional recovery, 2 dogs exhibited no neurological improvement, and 2 dogs with NDD deteriorated neurologically, postoperatively. The relationship between surgical outcomes and vertical or horizontal dispersion was not significant ($P > 0.05$). However, cases with a better preoperative neurological status had a better surgical outcome ($P < 0.05$).

Recurrence was seen in 2 dogs: one of them (dachshund — 5-y-old — case 16, [Table 1]) deteriorated neurologically by day 15 after an operation at L_{1-2} IVD. In its 2nd MRI, a DD type disk disease was diagnosed in the adjacent IVD (T_{13}-L_1). This case was reoperated on and the result was favorable. The other case (Pekingese — 5-y-old — case number 4) presented with nonambulatory tetraparesis 13 mo later and a C_{2-3} disk extrusion was diagnosed by cervical myelography. This case improved after ventral cervical slotting.

Discussion

Compressive or concussive trauma, or both, to the spinal cord caused by EDM is responsible for the clinical signs related to canine IVDD (5,10). The presence of hemorrhage is to be expected, since paired spinal venous sinuses lying dorsal to the IVD are likely to be damaged during herniation (10,29). When the small amount of EDM is in the form of a thin layer of hemorrhagic, necrotic, and granular material in the epidural space, it can be tolerated since it has a less harmful compressive effect when it is dispersed than when it is not dispersed. Nevertheless, the velocity of the extrusion causes concussive trauma, resulting in sudden paralysis and concomitant lesions and clinical signs. The inflammatory response to the extruded disk material can be expected to occur over a larger area with a DD than with a NDD. With a DD extrusion, the initial clinical signs are more likely due to a concussive rather than a compressive effect. These conclusions were based on the horizontal height of the EDM, and the vertical dispersion values of the laterally localized EDM, which were significant. However, with a NDD, the effect on the neural structures might be compressive rather than concussive. The more compact and calcified structure of the EDM in the NDD would account for the compression, whereas with the DD the extrusion of material is probably relatively slow.

Myelography, which is the common method for locating disk material in the vertebral canal (6,13,14,21), is invasive and has the potential to cause side effects, such as seizure and exacerbation of neurological signs (30–33). Whereas, Sether et al (16) studied herniated disks with MRI in 18 dogs, for the purpose of improving the interpretation, without observing any side effects. Moreover, our study showed complete accordance between MRI and surgical findings, enabled the subclassification of IVDD into DD and NDD, provided the precise orientation of the EDM, and allowed recognition of the other pathological changes related to the spine. Olby et al (29) suggested that thinning of contrast medium over a long distance, cranial and caudal to the disk herniation (indicates DD), might represent not solely spinal cord swelling but also hemorrhage. The authors conclusions are parallel to those of Olby et al (29). Dispersed disk (even in small size) and hemorrhage, and other related pathology were revealed and quantitative estimation of the extent of ED was carried out by MRI in this study.

The superiority of MRI in imaging IVDD and spinal cord injury is clear in human neurosurgery (34,35). Long-term compression of the spinal cord results in gliosis and myelomalacia; these changes are seen as focal areas of increased signal intensity in T_2-weighted images, as in cases of concussion and edema of acute injury (34). In this case series, increased signal intensity was observed in 11 cases; since most of these cases had been admitted during the first 4 d after observation of clinical signs, the cause of the increased signal intensity was assumed to be due to edema/concussion. However, the differentiation of myelomalacia from edema in MRI is difficult. Patients with increased signal intensity had poorer surgical outcomes, and these findings show that MRI is not only a reliable method for imaging the spine but also for predicting the prognosis.

The relationship between clinical signs and spinal cord compression according myelographic measurements has been reported (22). In that study, 80% of the dogs had different degrees of spinal cord compression, but the discrepancy between neurological findings and the spinal cord compression was obvious. Lateral disk extrusion that causes pain or other clinical signs associated with nerve root compression, without showing distinct myelographic lesions, have also been reported (36). The precise localization and estimation of EDM and related lesions were revealed by MRI in these cases. The mean of horizontal length of the EDM and lateral compression were greater in DD than in NDD, because the small fragments of EDM were spread over the epidural space as a thin layer. The velocity and the structural properties of the EDM and the animal's movement might have an effect on lateral localization. However, there was no significant difference between the effects of NDD and DD type disk disease on the preoperative neurological status and surgical outcomes.

The selection of surgical procedure depends on the localization of the lesion and the surgeon's preference. When lateralization is present, hemilaminectomy is preferred to laminectomy. The main advantages of hemilaminectomy are a smaller affected area due to the operation, intact spinous process, intact lamina and one side of the spinal canal, short postoperative convalescence period, and epidural fibrosis (7,37–40). In this study, the extent and localization of the EDM (central, left, or right) were found to be reliable parameters on which to determine operative techniques. Magnetic resonance imaging enabled the decision between hemilaminectomy and laminectomy, and the length of the decompression defect, to be defined preoperatively.

After decompression surgery, success rates have ranged from 58.85% to 95% (20). Differences in the recovery rates of preoperatively nonambulatory dogs varied according to the time interval from initial clinical signs to surgery, the severity of neurological disfunction, and the presence or absence of deep pain perception (3,4,7,41). We concluded from our study that there was complete recovery in 72.50% of cases, neurological improvement in 17.50%, and lack of neurological improvement in 10.00%. The MRI was found to be especially helpful in DD cases, since the thinness and extent of the EDM is the determining factor in diagnosis, prognosis, and choosing treatment models. Even though Olby et al (29) indicated that a thin layer of EDM can be treated conservatively, in our study, surgical intervention had been preferred over conservative treatment after considering the inflammatory reaction, the deterioration of neurological status, and the longer recovery time.

The recurrence of IVDD resulting in subsequent disk herniation at a site different from the initial lesion has been reported in several instances (24,29), and prophylactic disk fenestration has been suggested by some authors (25,42). In this case series, recurrence was observed only in 2 cases: an adjacent IVD was affected in 1, an irrelevant disk was diseased in the other. According to these 2 cases, it cannot be speculated that prophylactic disk fenestration should be done.

In conclusion, the precise diagnosis of canine IVDD was demonstrated in detail by MRI. Decompression with retrieving EDM can be suggested as a surgical treatment choice for canine IVDD. There was not any significant difference between DD and NDD according to preoperative neurological status and surgical outcomes ($P > 0.05$). The removal of EDM from the epidural space exposed by decompression was easier in DD than in NDD cases. CVJ

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